



## Unexpected effects of mesoporosity on the catalytic performance of ZSM-5 for the fast pyrolysis of cellulose to aromatic hydrocarbons

Hoff, Thomas C.; Gardner, David W.; Thilakaratne, Rajeeva; Proano-Aviles, Juan; Hansen, Thomas Willum; Brown, Robert C.; Tessonnier, Jean Philippe

*Publication date:*  
2017

*Document Version*  
Peer reviewed version

[Link back to DTU Orbit](#)

### *Citation (APA):*

Hoff, T. C., Gardner, D. W., Thilakaratne, R., Proano-Aviles, J., Hansen, T. W., Brown, R. C., & Tessonnier, J. P. (2017). *Unexpected effects of mesoporosity on the catalytic performance of ZSM-5 for the fast pyrolysis of cellulose to aromatic hydrocarbons*. Abstract from 253rd ACS National Meeting, San Francisco, California, United States.

---

### General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

## Unexpected effects of mesoporosity on the catalytic performance of ZSM-5 for the fast pyrolysis of cellulose to aromatic hydrocarbons

Thomas C. Hoff,<sup>1</sup> David W. Gardner,<sup>1</sup> Rajeeva Thilakaratne,<sup>2</sup> Juan Proano-Aviles,<sup>2</sup> Thomas W. Hansen,<sup>3</sup> Robert C. Brown,<sup>2</sup> Jean-Philippe Tessonnier<sup>1</sup>

<sup>1</sup>Chemical and Biological Engineering, Iowa State University, Ames, IA, United States

<sup>2</sup>Bioeconomy Institute, Iowa State University, Ames, IA, United States

<sup>3</sup>Center for Electron Nanoscopy, Technical University of Denmark, Lyngby, Denmark

Catalytic fast pyrolysis (CFP) represents a sustainable method to convert raw biomass into useful chemicals and fuels in a single step. ZSM-5 has been identified as the best catalyst for this reaction, producing hydrocarbons with a high selectivity to benzene, toluene, xylene, and naphthalene. Yet, the corresponding yields remain low (~ 30 C%) and a significant fraction of carbon is lost in the form of coke. It has been hypothesized that coke formation is primarily due to transport limitations and may be addressed by introducing mesopores in the zeolite crystals. We tested this hypothesis by synthesizing mesoporous ZSM-5 through top-down (desilication of commercial zeolite) and bottom-up (laboratory synthesized samples) methods. Our results revealed a significantly more complex interplay of various parameters, including crystallinity, elemental composition, porosity, and acidity. The introduction of mesopores was typically accompanied by an alteration of the zeolite's structure and the formation of amorphous species that hinder the diffusion of bulky oxygenates under reaction conditions. Combining ten different characterization techniques revealed that crystallinity and aluminum site accessibility are critical to achieve high aromatic yields. As a result, large microporous ZSM-5 crystals afford higher aromatic hydrocarbon yields than mesoporous ZSM-5.

1. T. C. Hoff, D. W. Gardner, R. Thilakaratne, K. Wang, T. W. Hansen, R. C. Brown, J.-P. Tessonnier, Tailoring ZSM-5 Zeolites for the Fast Pyrolysis of Biomass to Aromatic Hydrocarbons, *ChemSusChem*, **2016**, 9, 1473-1482. <http://dx.doi.org/10.1002/cssc.201600186>

2. T. C. Hoff, R. Thilakaratne, D. W. Gardner, R. C. Brown, J.-P. Tessonnier, Thermal Stability of Aluminum-Rich ZSM-5 Zeolites and Consequences on Aromatization Reactions, *J. Phys. Chem. C*, **2016**, 120, 20103-20113. <http://dx.doi.org/10.1021/acs.jpcc.6b04671>

3. T. C. Hoff, D. W. Gardner, R. Thilakaratne, J. Proano-Aviles, R. C. Brown, J.-P. Tessonnier, Elucidating the Effect of Desilication on Aluminum-Rich ZSM-5 Zeolite and Its Consequences on Biomass Catalytic Fast Pyrolysis, *Appl. Catal. A*, **2017**, 529, 68-78. <http://dx.doi.org/10.1016/j.apcata.2016.10.009>